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Economic Evaluation

Market Consolidation and Mortality in Patients Initiating Hemodialysis

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A B S T R A C T

Background: It is uncertain whether consolidation in health care markets affects the quality of care provided and health outcomes. **Objectives:** To examine whether changes in market competition resulting from acquisitions by two large national for-profit dialysis chains were associated with patient mortality. **Methods:** We identified patients initiating in-center hemodialysis between 2001 and 2009 from a registry of patients with end-stage renal disease in the United States. We considered two scenarios when evaluating consolidation from dialysis facility acquisitions: one in which we considered only those patients receiving dialysis in markets that became substantially more concentrated to have been affected by consolidation, and the other in which all patients living in hospital service areas where a facility was acquired were potentially affected. We used a difference-in-differences study design to examine the associations between market consolidation and changes in mortality rates. **Results:** When we considered the 12,065 patients living in areas that became substantially more consolidated to

have been affected by consolidation, we found a nominally significant (8%; 95% confidence interval 0%–17%) increase in likelihood of death after consolidation. Nevertheless, when we considered all 186,158 patients living in areas where an acquisition occurred to have been affected by consolidation, there was no observable effect of market consolidation on mortality. **Conclusions:** Decreased market competition may have led to increased mortality among a relatively small subset of patients initiating in-center hemodialysis in areas that became substantially more concentrated after two large dialysis acquisitions, but not for most of the patients living in affected areas.

Keywords: end-stage renal disease, dialysis provider, market competition, mortality

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Introduction

Many health care markets have become increasingly consolidated [1,2]. Although health care market consolidation often leads to higher prices [3–5], its effects on the quality of care provided and health outcomes are less certain [6–9].

More than 85% of patients with end-stage renal disease (ESRD) receiving dialysis are covered by Medicare. Because Medicare administers prices through reimbursement policy, dialysis providers must find ways to attract patients to their facilities other than through offering reduced prices to insurers. Potential associations among competition, quality of care, and health outcomes may be the strongest in markets such as for dialysis, in which predominantly fixed prices may encourage competition on quality rather than on price [3,10].

Many local dialysis markets became more concentrated over the past 15 years, primarily because of acquisitions by two large for-profit dialysis chains. In 2011, more than 25% of patients had fewer than two nearby dialysis facilities to choose from, and most local dialysis markets were highly concentrated by Federal Trade Commission (FTC) standards [11]. Dialysis markets can become concentrated for various reasons, including closures and acquisitions. Dialysis facility closures have, however, been relatively rare, and areas affected by closures may be different in important ways from other areas affected by consolidation [12,13]. In this study, we examined whether consolidation in US dialysis markets resulting from two large national dialysis acquisitions announced in 2004 affected the likelihood of death among patients initiating in-center hemodialysis in the hospital service areas (HSAs) where facilities were acquired. We focused on mortality during the first

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18 months of dialysis, because this is a time when many patients are the least stable clinically [14] and would be most susceptible to health consequences from changes in quality of care.

Methods

Data Sources

We identified patients receiving in-center hemodialysis between 2001 and 2009 from a US national ESRD registry. Patient comorbidity information came from the Centers for Medicare & Medicaid Services (CMS) Medical Evidence Report (CMS-2728), which nephrologists complete at the onset of ESRD. Information about large dialysis chain ownership came from annual facility surveys, whereas information about smaller chain ownership came from the CMS Dialysis Facility Compare. We linked patient zip codes to census-based rural urban commuting area codes [15] and data from the Dartmouth Atlas Project [16] to identify population density and to assign patients to HSAs.

Patient Selection

We analyzed two major acquisitions by for-profit US dialysis chains announced in 2004: 1) Fresenius Medical Care's acquisition of Renal Care Group (RCG) [17] and 2) DaVita's acquisition of Gambro Health Care's US facilities [18]. More than 80% of facilities owned by RCG in 2005 were reported to be owned by FMC (or National Renal Institutes because of forced divestiture) by 2007, whereas more than 80% of facilities owned by Gambro in 2004 were owned by DaVita (or Renal Advantage because of forced divestiture) in 2006 [18]. We considered facilities that changed ownership during these periods to have been acquired. We defined "transition periods" for the Fresenius and DaVita acquisitions as 2005 to 2006 and 2004 to 2005, respectively.

By focusing on consolidation resulting from two large acquisitions, we follow the same approach that has been used in previous studies of the effects of market consolidation in the insurance industry in multiple local markets across the country, such as an analysis of the effects of Aetna's acquisition of Prudential [5,19]. Although mergers and acquisitions have legally distinct definitions, the primary concern in both cases is the resulting impact of consolidation on patient welfare. Moreover, this form of consolidation is becoming more common in the health care sector, including several recent large vertical acquisitions, with the potential acquisition of Aetna by CVS [20] and Humana's acquisition of Kindred Healthcare [21].

We selected patients initiating in-center hemodialysis in the 3 years before and after each major acquisition. We designated patients initiating dialysis from 2002 to 2004 and from 2007 to 2009 as potentially affected by Fresenius' acquisition of RCG, and patients initiating dialysis from 2001 to 2003 and from 2006 to 2008 as potentially affected by DaVita's acquisition of Gambro. We considered patients initiating dialysis from 2001 to 2004 and from 2006 to 2009 to be in the "preacquisition" and "postacquisition" periods, respectively. Because competition for patients can influence all facilities operating in a market [22], we considered all patients living in an HSA where a facility was acquired as potentially affected by an acquisition, regardless of whether they initiated dialysis at the acquired facility. Because we were interested in the overall effect of consolidation, rather than in the effect of a particular acquisition, we combined the two acquisition cohorts by assigning patients to the acquisition with the largest effect on measured competition in their locality (Fig. 1).

We excluded patients living in HSAs where an acquired facility was not reported to change ownership by the first year of the relevant postacquisition period. We required that patients lived

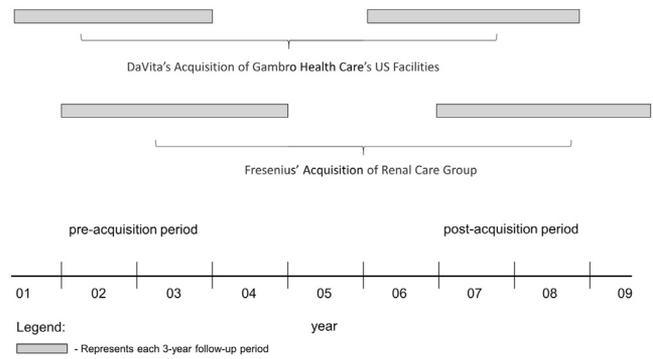


Fig. 1 – Model selection diagram. Patients were selected if they started dialysis in the preacquisition or postacquisition period for a given acquisition group. Patients were censored at the end of their assigned preacquisition or postacquisition period.

and received in-center hemodialysis for 90 days to identify a stable in-center hemodialysis population [23] and assigned patients to dialysis facilities and zip codes on the basis of where they lived and received dialysis after 90 days of dialysis.

Market Competition Measurement

On January 1 of each year, we identified all prevalent patients receiving in-center hemodialysis and their dialysis facilities and calculated a commonly used metric of market competition—the Herfindahl-Hirschman index (HHI)—for local dialysis markets. The HHI ranges from near 0 (perfectly competitive markets) to 1 (monopolistic markets). We adopted a method used to calculate HHI in health care markets that accounts for patients' decisions to dialyze outside of the HSA where they live [4,9,24] and that reflects the numbers of nearby competing facilities from which patients can choose [11]. We assumed that facilities that share ownership do not compete against one another for patients.

For each HSA, we calculated the average HHI in the 3 years before and after each acquisition. To focus on areas where acquisitions would be more likely to lead to consolidation, and where providers would be more likely to respond to changes in competition, we restricted our study to patients initiating dialysis in HSAs that were highly concentrated (average HHI ≥ 0.25)—as defined by FTC guidelines—in the period before each acquisition [25].

Exposure Groups

The main study exposure was market consolidation resulting from dialysis facility acquisitions. We applied two criteria to determine whether patients were affected by an acquisition, leading to two exposure groups. In our primary exposure group, we considered patients to be affected by consolidation if they lived in an HSA where an acquisition led to a "substantial" increase in HHI, defined as an average increase of 0.1 or more. This is the magnitude of increase considered by the FTC to raise significant anticompetitive concerns in highly concentrated markets [25]. In an alternative exposure group, we examined all acquisitions in highly concentrated areas, regardless of the change in HHI. Our rationale for including a much broader exposure group is analogous to the adoption of the intention-to-treat principle in clinical trials—we hoped to assess the potential effect of changes in market concentration from acquisitions without obligating that

acquisitions had the expected effect on market concentration or whether acquisitions led the FTC to require divestiture.

For each exposure group, we considered all remaining patients who started in-center hemodialysis and who lived for at least 90 days to be unaffected by consolidation. This included patients initiating dialysis in nonaffected HSAs from 2002 to 2004 and 2007 to 2009 or from 2001 to 2003 and 2006 to 2008. We assigned each unaffected patient to a specific acquisition (i.e., Fresenius' acquisition of RCG or DaVita's acquisition of Gambro) on the basis of the year of dialysis initiation. In instances when an unaffected patient could be assigned to either acquisition, we randomly assigned them to an acquisition group (see the Appendix in [Supplemental Materials](https://doi.org/10.1016/j.jval.2018.06.008) found at <https://doi.org/10.1016/j.jval.2018.06.008>).

Study Outcomes and Covariates

The main study outcome was time to death. We followed patients for the first 18 months of dialysis or until the end of the 3-year preacquisition or postacquisition window within which they initiated dialysis. We censored patients if they moved to a new HSA for more than 60 days or recovered renal function. We controlled for patient, geographic, and dialysis facility characteristics presented in [Table 1](#), including dialysis at each of the largest five dialysis chains. We used multiple imputation to account for missing data on albumin, hemoglobin, and body mass index [26].

Study Design

We used difference-in-differences (DID) models to estimate the effect of industry consolidation on patient mortality [22]. In the context of a DID analysis, we compared changes in mortality rates after consolidation among patients living in areas that were and were not affected by consolidation. We conducted separate DID analyses using the two exposure groups outlined earlier. In Cox proportional hazards models, a variable denoting the interaction between being affected by consolidation and initiating dialysis in the postconsolidation period characterized the estimated effect of consolidation on mortality. Because the preacquisition and postacquisition periods spanned different years depending on the acquisition, we included dummy variables for each calendar year.

Additional Analyses

Dialysis facility acquisitions can influence care delivery and patient health for reasons unrelated to changes in market competition. For example, new owners may provide a different quality of care, or transitioning ownership may disrupt care for some patients. If the patient, geographic, and dialysis facility characteristics included in our regression models do not fully account for these differences, observed associations between consolidation and mortality could reflect changes in competition or the acquisitions themselves. To address this challenge, we conducted analyses where we excluded patients starting dialysis at acquired facilities. Similar to our primary models, we compared patients living near to acquired facilities (i.e., in the same HSA) with patients living in areas where no acquisitions occurred. This approach has been used to examine changes in competition resulting from consolidation in other health care markets [22].

We also examined whether the association between consolidation and mortality depends on the magnitude of change in competition among the subset of patients initiating dialysis in HSAs affected by facility acquisitions. We did this by including indicator variables in our Cox models representing different magnitudes of change in HHI after acquisitions (≤ 0 , 0–0.05, 0.05–0.1, and >0.1). We included interaction terms denoting whether patients started dialysis in the postconsolidation period in each category of HHI change, and compared estimates associated with these interaction terms. We examined this relationship

in separate analyses in which we included, and excluded, patients at facilities that were acquired.

It is possible that the effect of consolidation on patient health outcomes varies over time, as the consequences of staff and management changes evolve. We examined this possibility in an analysis in which we included separate time-varying interaction terms denoting whether patients started dialysis in areas affected by acquisition in each postacquisition year. Finally, we examined whether the effect of consolidation varied across the two major acquisitions (see the [Appendix in Supplemental Materials](#)).

This project was approved by an institutional review board at Baylor College of Medicine (ID no. H-36408).

Results

Baseline Characteristics

In both exposure groups, approximately 20% of patients initiating dialysis in the preconsolidation period died during follow-up, compared with 19% in the postconsolidation period. The unadjusted mortality rate was slightly lower among patients initiating dialysis in the period after acquisitions, regardless of whether patients lived in an area that was affected by consolidation (see [Appendix Figure 1 in Supplemental Materials](#) found at <https://doi.org/10.1016/j.jval.2018.06.008>).

In our examination of patients affected by consolidation who lived in HSAs with an HHI increase of 0.1 or more, 12,065 patients (2.4% of total) were affected by consolidation and 500,760 were unaffected. Using a *P* value of less than 0.01 as a marker of heterogeneity across comparison groups, differences over time among patients who were and were not affected by consolidation were balanced across all categories, except for the mean dialysis facility size, which decreased over time in HSAs not affected by consolidation and increased over time in affected HSAs ([Table 1](#)). The mean HHI in the period before acquisitions was 0.48 and 0.51 among patients living in areas that were and were not affected by consolidation, respectively. The mean HHI increased by 0.162 among patients affected by consolidation, and decreased by 0.001 among unaffected patients ([Fig. 2](#)).

When we considered all patients who lived in an HSA where a facility was acquired to be affected by consolidation, 186,158 (36.3%) patients initiated dialysis in affected HSAs, whereas 326,667 patients were unaffected. In this exposure group, covariates were less balanced among patients who were and were not affected by consolidation ([Table 2](#)). The mean HHI in the period before acquisitions was 0.45 and 0.55 among patients living in areas affected and unaffected by consolidation, respectively. The mean HHI increased by 0.013 among patients affected by consolidation, and decreased by 0.003 among patients unaffected by consolidation ([Fig. 2](#)).

Regression Results

In our primary analysis of patients affected by consolidation who lived in HSAs where the HHI increased by 0.1 or more, there was no significant difference in mortality between affected and unaffected patients at baseline (hazard ratio [HR] 0.98; 95% CI 0.93–1.04). Affected patients experienced a nominally significant 8% increase in hazard of mortality after acquisitions relative to unaffected patients (HR 1.08; 95% CI 1.00–1.17) ([Fig. 3](#); see also [Appendix Table 1 in Supplemental Materials](#) found at [doi:10.1016/j.jval.2018.06.008](https://doi.org/10.1016/j.jval.2018.06.008)). When we considered all patients living in an HSA where an acquisition occurred to have been affected by consolidation, we did not observe an association between acquisitions and mortality ($p_{\text{interaction}} = 0.96$) (see [Appendix Table 2 in Supplemental Materials](#) found at [doi:10.1016/j.jval.2018.06.008](https://doi.org/10.1016/j.jval.2018.06.008)).

Table 1 – Baseline characteristics among patients in areas with largest declines in market competition

Characteristic	Not affected by consolidation			Affected by consolidation			P value (DID)
	Preperiod	Postperiod	Difference [†]	Preperiod	Postperiod	Difference [†]	
Number of patients	234,622	266,138		5,672	6,393		
Patient demographic and socioeconomic characteristics							
Age	62.7	62.6	−0.1	63.0	62.8	−0.2	0.61
Male	53.9	55.9	2.0	52.4	55.6	3.3	0.17
Native American	1.3	1.2	−0.1	0.5	0.6	0.1	0.42
Black	29.0	29.2	0.2	33.1	33.6	0.5	0.67
White	63.7	65.0	1.3	62.7	63.5	0.8	0.60
Other race	6.0	4.7	−1.4	3.7	2.2	−1.4	0.89
Hispanic ethnicity	12.3	14.5	2.2	8.3	11.2	2.9	0.23
Employed	9.2	10.5	1.3	7.4	9.4	1.9	0.25
Medicaid	25.3	25.8	0.5	26.3	27.2	0.9	0.61
Patient health characteristics							
Diabetes	51.2	55.2	4.0	52.1	55.1	3.0	0.28
Coronary artery disease	26.7	20.9	−5.9	29.1	23.9	−5.2	0.42
Cancer	5.8	6.8	1.0	6.0	7.1	1.2	0.66
Heart failure	32.4	32.9	0.5	36.4	36.3	0.0	0.51
Lung disease	7.8	8.8	1.0	8.5	9.3	0.8	0.70
Cerebrovascular disease	9.1	9.5	0.4	10.0	9.7	−0.2	0.25
PVD	14.7	13.9	−0.8	17.2	15.9	−1.3	0.39
Immobility	3.7	6.2	2.5	4.5	7.0	2.5	0.94
Smoker	5.2	6.4	1.2	5.0	6.8	1.8	0.21
Drug or alcohol abuse	1.9	2.5	0.6	1.6	2.3	0.8	0.52
Body mass index (kg/m ²)	27.7	29.0	1.3	28.1	29.3	1.2	0.28
Hemoglobin (g/dl)	9.9	10.0	0.1	10.0	10.0	0.0	0.89
Serum albumin (g/dl)	3.1	3.1	0.0	3.1	3.1	0.0	0.57
Dialysis facility and geographic characteristics							
Facility size (patients)	95.1	92.7	−2.4	94.0	95.3	1.3	0.001
For-profit	78.1	80.7	2.6	90.3	92.7	2.5	0.85
Hospital-based	14.1	11.8	−2.2	6.4	3.9	−2.4	0.73
Metropolitan	80.2	80.1	−0.1	72.4	72.1	−0.2	0.87
Micropolitan	11.6	11.4	−0.2	17.9	17.8	−0.1	0.91
Small town	4.8	4.7	−0.1	6.0	6.4	0.3	0.26
Rural	3.4	3.3	−0.1	3.7	3.7	0.1	0.71

Note. We excluded patients receiving dialysis at Veterans Affairs, prisons, and military facilities, who were less likely to have a choice about where they received dialysis. P values are obtained from estimates of the interaction term from univariate linear regression analyses where each characteristic is regressed against 1) consolidation vs. no consolidation, 2) preconsolidation vs. postconsolidation, and 3) their interaction. DID, difference-in-differences; PVD, peripheral vascular disease.

[†] Difference is the absolute difference between the preperiods and postperiods.

Additional Analyses

In an analysis in which we excluded patients dialyzed at facilities that were directly involved in acquisitions, we found that consolidation led to a 13% increase in hazard of mortality (HR 1.13; 95% CI 1.01–1.26) in areas where the HHI increased substantially (>0.1). When examining the effect of consolidation across different strata of HHI change (among patients living in areas affected by consolidation), we found that mortality increased only after acquisitions in areas where the HHIs increased by 0.1 or more, but this increase was not statistically significant (Fig. 4). When examining for potential time-varying effects of consolidation, we found that consolidation was significantly associated with increased mortality in the first postconsolidation year (HR 1.12; 95% CI 1.02–1.24), but not in the subsequent 2 years. Nevertheless, a test for heterogeneity failed to demonstrate a statistically significant difference in the three postacquisition interaction terms.

There was nominally significant variation in the estimated effect of consolidation across the two major acquisitions (see the [Appendix in Supplemental Materials](#)).

Discussion

Traditional economic models predict that firms operating in less competitive markets are able to raise prices and earn higher profits. In cases in which prices are fixed by government policy, firms in less competitive markets may still be able to increase profits by reducing costs through providing lower quality products. Studies of consolidation in hospital markets in the 1990s and early 2000s found that less competition was more closely associated with lower quality of care and worse health outcomes in markets with fixed prices [3,10]. Our findings are consistent with this observation in hospital markets and suggest that less market competition may be associated with worse health outcomes in some highly concentrated dialysis markets in which prices are predominantly fixed by Medicare reimbursement policy.

Although the small number of patients initiating dialysis in highly concentrated areas where the HHI increased by more than 0.1 limited our ability to make definitive conclusions about the effect of market competition on mortality, our finding is concerning when considering ongoing consolidation in markets for dialysis and other health care services. For instance, in 2011

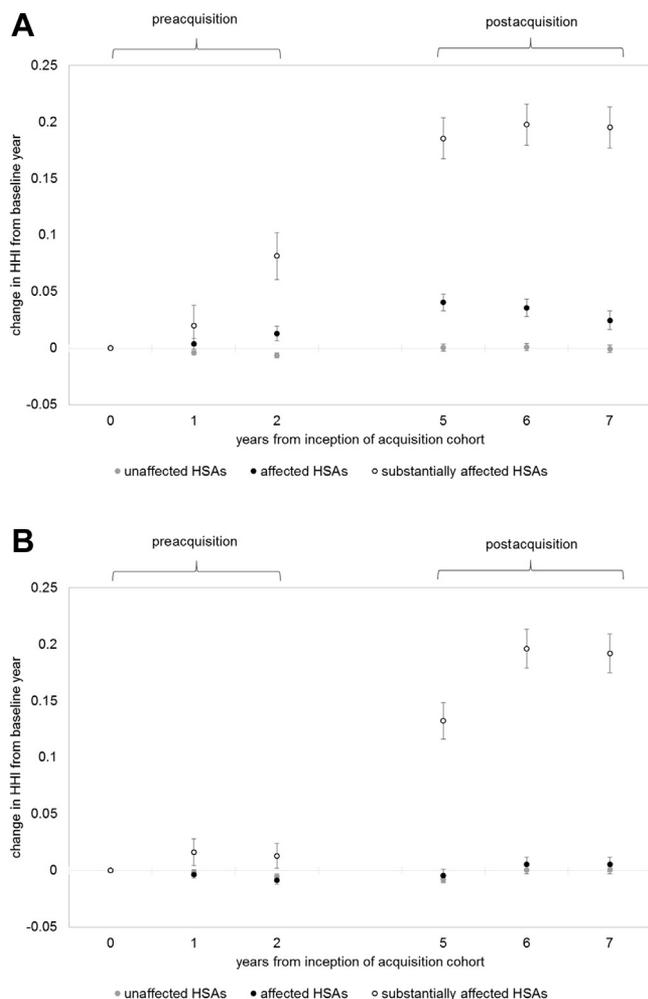


Fig. 2 – Change in index of market competition over time in areas affected by national acquisitions. Data are presented at the level of the HSA. Data points represent mean changes from baseline year (i.e., year 0). A and B illustrate changes in HHI in areas potentially affected by each of the two major acquisitions. Error bars represent standard errors of means. HHI, Herfindahl-Hirschman index; HSA, hospital service area.

DaVita acquired DSI Renal, Inc., which directly involved 106 dialysis facilities and approximately 8000 patients [27]. Later that year, Fresenius acquired Liberty Dialysis and Renal Advantage, which involved 260 dialysis facilities and approximately 19,000 patients [28]. As additional patient health data become available, it will be important to monitor the consequences of these and other more recent acquisitions in markets most affected by consolidation.

Our findings suggest that the health consequences associated with consolidation vary within and across markets and possibly over time. Dialysis facilities that are acquired may differ from those that are not acquired. Greater staffing intensity, lower facility capacity (i.e., fewer stations per patient), and larger size of markets predict acquisitions by large dialysis chains [29]. Improvements in management associated with transition from a poorly managed facility to a large dialysis chain could mask negative health consequences from decreased market

competition. Nevertheless, when we excluded patients at facilities that were acquired, we continued to observe an increase in mortality in regions that became substantially less competitive after acquisitions. We also observed that the health consequences from consolidation may have depended on which of the two major acquisitions affected an area, suggesting that changes in the delivery of care in response to market competition may depend on the acquiring facility (or chain).

When examining for time-varying effects of acquisitions, we found that increased mortality associated with acquisitions may have occurred only in the year immediately after acquisitions. It is possible that because of disruptions in facility operations, ownership change is a time when care delivery may be compromised, and when competition may have an important role in preserving high quality of care. Although we were unable to demonstrate that observed heterogeneity in the effect of consolidation was statistically significant, this secondary analysis may also have been limited by small numbers of patients in areas where acquisitions led to substantial market consolidation. It will be important for future studies to examine whether effects of market competition on quality of care are most pronounced during certain key times, such as when providers in a market undergo organizational change.

There are several possible reasons why we did not observe an association between acquisitions and mortality for most patients initiating in-center hemodialysis. First, in many instances dialysis facility acquisitions did not actually lead to more concentrated markets. We previously demonstrated that although the national market shares of the two largest dialysis providers have increased over time, patients did not—on average—face fewer choices among competing dialysis facilities in 2011 compared with 2001 [11]. In the present study, the mean HHI increased by only 0.016 in HSAs where acquisitions occurred compared with HSAs where acquisitions did not occur. It is also possible that in many areas where markets became more concentrated, dialysis facilities did not change how they cared for patients. Patients can be assigned to a dialysis facility for a number of reasons that may not change immediately in response to declining market competition. For example, nearly half of the patients receive dialysis at the facility closest to where they live [9]. A strong preference for receiving dialysis close to home may outweigh other benefits that dialysis facilities might offer in an effort to attract patients. Or, patients may be assigned to a dialysis facility on the basis of existing financial arrangements between a facility and physicians or hospitals, such as medical directorships and/or joint ventures. It may take longer than 3 years for changes in these relationships to reflect less competitive dialysis markets. Facilities may compete for patients by offering incentives unrelated to health outcomes. Two studies suggest that more competitive dialysis markets led primarily to more “amenities” available to patients (e.g., high-definition television, expanded entertainment options, and more comfortable chairs) [7,30]. Although more amenities may improve patients’ satisfaction with the care they receive, they are unlikely to influence major health outcomes such as mortality. Finally, regulatory efforts by the CMS and the ESRD Networks may ensure adequate quality of care in most markets irrespective of competition.

Our study design addressed two common sources of bias that can occur in observational studies examining the health consequences of market competition. First, our use of DID enabled us to designate each group that was either affected or unaffected by consolidation as its own “control,” eliminating bias from unobserved differences between these comparison groups that do not change over time. Second, bias can occur when examining the association between metrics of market competition and health outcomes if patients choose to receive care from higher quality providers [5]. Nevertheless, any changes over time in the

Table 2 – Baseline characteristics among patients in all areas affected by consolidation

Characteristic	Not affected by consolidation			Affected by consolidation			P value (DID)
	Preperiod	Postperiod	Difference [†]	Preperiod	Postperiod	Difference [†]	
Number of patients	154,119	172,548		86,175	99,983		
Patient demographic and socioeconomic characteristics							
Age	63.1	63.1	0.0	62.1	61.9	−0.2	0.02
Male	54.2	56.2	2.0	53.3	55.4	2.1	0.60
Native American	1.5	1.4	−0.1	0.8	0.8	−0.1	0.68
Black	25.1	25.2	0.1	36.3	36.4	0.0	0.63
White	67.0	68.2	1.2	57.6	59.2	1.7	0.08
Other race	6.4	5.2	−1.2	5.2	3.6	−1.6	0.003
Hispanic ethnicity	10.8	12.7	1.9	14.8	17.4	2.6	0.002
Employed	9.2	10.4	1.3	9.3	10.7	1.4	0.34
Medicaid	24.6	25.1	0.5	26.7	27.2	0.5	0.90
Patient health characteristics							
Diabetes	51.3	55.6	4.3	51.0	54.5	3.4	0.004
Coronary artery disease	28.4	22.6	−5.8	23.9	18.1	−5.8	0.75
Cancer	6.1	7.2	1.1	5.2	6.1	0.8	0.08
Heart failure	33.5	33.7	0.2	30.5	31.6	1.1	0.001
Lung disease	8.5	9.6	1.1	6.7	7.6	0.9	0.30
Cerebrovascular disease	9.5	9.8	0.3	8.5	9.1	0.6	0.09
PVD	15.7	14.9	−0.9	13.0	12.4	−0.6	0.16
Immobility	3.8	6.3	2.5	3.5	6.1	2.5	0.80
Smoker	5.5	6.7	1.2	4.6	6.0	1.4	0.09
Drug or alcohol abuse	1.8	2.4	0.6	2.0	2.6	0.6	0.82
Body mass index (kg/m ²)	27.7	29.1	1.4	27.6	28.9	1.3	0.17
Hemoglobin (g/dl)	10.0	10.0	0.0	9.9	9.9	0.1	0.03
Serum albumin (g/dl)	3.1	3.1	0.0	3.1	3.1	0.0	0.002
Dialysis facility and geographic characteristics							
Facility size (patients)	93.7	91.8	−2.0	97.4	94.5	−2.9	0.01
For-profit	73.8	76.9	3.1	86.7	88.1	1.4	<0.001
Hospital-based	17.2	14.0	−3.2	7.9	7.6	−0.3	<0.001
Metropolitan	75.5	75.5	0.0	88.1	87.5	−0.6	0.01
Micropolitan	14.5	14.2	−0.2	6.9	7.0	0.1	0.04
Small town	5.8	5.8	−0.1	3.0	2.8	−0.1	0.52
Rural	4.2	4.1	−0.1	2.0	2.0	0.0	0.49

Note. We excluded patients receiving dialysis at Veterans Affairs, prisons, and military facilities, who were less likely to have a choice about where they received dialysis. P values are obtained from estimates of the interaction term from univariate linear regression analyses where each characteristic is regressed against 1) consolidation vs. no consolidation, 2) preconsolidation vs. postconsolidation, and 3) their interaction. DID, difference-in-differences; PVD, peripheral vascular disease.

[†] Difference is the absolute difference between the preperiods and postperiods.

perceived quality of care delivered in dialysis markets would likely have been related to changing ownership due to acquisitions. It is reassuring, therefore, that our findings did not change noticeably when we excluded patients initiating dialysis at facilities that were acquired.

This study has several limitations. We focused on the effect of industry consolidation on mortality that can be explained by changes in competition. Although understanding the independent effect of market competition on quality of care delivered and mortality is important, particularly given more recent consolidation in dialysis markets and other markets for health care services, this is only one way in which acquisitions and consolidation may affect patient health. For instance, competition in dialysis markets may also be associated with hospitalizations, including hospitalization for infection [31]. In our primary analyses, we did not attempt to disentangle the effects of consolidation versus management change from acquisitions on patient health. It is reassuring, however, that our findings did not change substantively in a sensitivity analysis in which we excluded facilities that were actually acquired. We did not examine the specific

mechanisms by which changes in competition may have affected care delivery and mortality. We also did not study whether consolidation influenced providers' decisions regarding how to deliver dialysis (dialysis modality), patients' satisfaction with the care they receive, or access to care. Finally, observed imbalances in characteristics in our analysis of all acquisitions suggest that the treatment and control groups in this comparison may have also changed in unobserved ways, which could lead to bias.

For patients who initiated in-center hemodialysis in highly concentrated US dialysis markets between 2001 and 2009 when acquisitions by two large dialysis chains led to substantial increases in market consolidation, we found a nominally significant relative increase in mortality risk of 8%. The estimated increase in mortality was larger (13%) and was statistically significant when we excluded patients initiating dialysis at facilities that were acquired. Nevertheless, increased consolidation of this magnitude affected only a small subset of patients initiating hemodialysis. For most of the patients living in areas where an acquisition occurred, we did not find evidence that acquisitions affected the risk of death. The observed association between consolidation

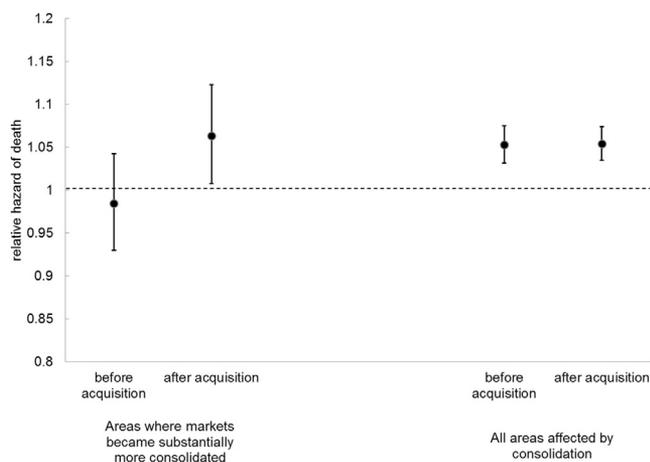


Fig. 3 – Estimated change in hazard of death among patients affected by consolidation relative to unaffected patients. Dotted line represents hazard of death before and after acquisition among patients unaffected by acquisitions.

and mortality may have been limited to the time period immediately after acquisitions or could be due to chance.

Conclusions

Our finding that industry consolidation resulting from two large national dialysis chain acquisitions may have led to increased mortality in areas where dialysis markets became substantially less competitive after acquisitions suggests that market competition may have an important role in preserving the quality of care

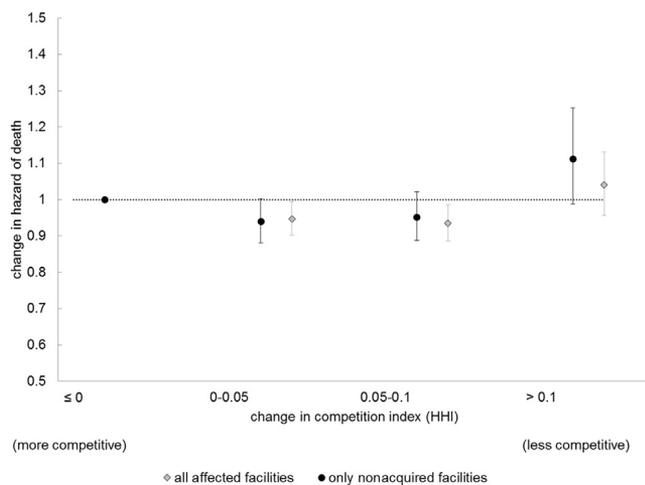


Fig. 4 – Estimated changes in mortality after acquisitions stratified by change in market concentration. Analysis includes all patients in hospital service areas where acquisition occurred. Estimates are from a Cox regression model identical to our primary analytic model, except that the category of HHI change is interacted with the postacquisition period to generate the illustrated estimates. HHI, Herfindahl-Hirschman index.

in health care markets in which prices are predominantly fixed by government reimbursement policy. This may be particularly relevant during periods of organizational transition. It will be important to identify areas where more recent—and future—acquisitions have the most substantial effect on market competition to assess for potential downstream effects on quality of care and health outcomes.

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Supplementary Materials

Supplementary data associated with this article can be found in the online at <https://doi.org/10.1016/j.jval.2018.06.008>.

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